Abstract and Introduction

A good business use of a graph is to display visually the relative size of measurements, and to supply the numbers at the same time. Presentations or management reports that integrate image (i.e., impact) and numbers (i.e., precision) are memorable, quickly and easily comprehended, and usable for decision support. Pie charts and bar charts are popular ways to try to do this, but are best created with care. And SAS/GRAPH defaults or inappropriate “special effects” can be unacceptable for effective display of image and/or numbers.

This tutorial on graphic communication shows how design principles and the best use of options yield powerful presentation materials, and easily digested reports. It discusses design, and shows graphs and supporting SAS code, but the SAS code will have been explained orally only. Included are some simple techniques to overcome limitations of SAS/GRAPH, as well as recommendations as to when to use pie charts versus bar charts versus line plots versus tables.

On Communication

“Put it before them--briefly . . . so they will read it, clearly . . . so they will appreciate it, picturesquely . . . so they will remember it, and, above all, accurately . . . so they will be guided by its light.”

Joseph Pulitzer

“Simplicity has power.”

LeRB

Defaults vs. Customization

The time and the attention of the graph viewer are precious resources, for her or for him, and for you.

- Software & hardware = power tools, but potentially lots of sub-optimal results quickly
- Software defaults acceptable? Analysis of data: sometimes presentation of information: rarely
- Defaults = quick success, if undemanding (See Figures 2 & 4)
- Astute customization = more effective graphs (See Figures 3 & 5)

Special Effects

- Good design & interesting data can stand on their own
- Productivity & communication are the real objectives
- Save time & computer resources by avoiding frills (e.g., 3D)
- 3D pie charts--always distortion
- 3D bar charts--needless complexity
- Only need for 3D: plot of 3 variables

Text on Graphs

- Always black--most readable
- Emphasize with italics (or bold), not color
- Preferred fonts: hardware characters, or TRIPLEX, or XSWISS
- Text uses resources (if fancy, lots)--keep it brief
- Focus viewer attention with sparse text

Labels, Text, Decimals

- SAS variable name an unacceptable label
- Unless compelling counter-need, use upper & lower case
- Mixed case: business communication standard, and easier to read
- All upper case: hold-over from primitive computer printing
- Not doing science--usually suppress decimals

Area Fill: When?

- Area fill uses resources
- If color/pattern carries no information, usually leave area empty, unless color presentation required
- If simple bar, maybe light grey shade, especially if bars close together (solid bars dominate the page, empty bars cause visual confusion)
- If SAS/GRAPH ever supports a pie legend, pie slice color could be useful (especially when large number of slices)
Area Fill: How? (Figures not printed)
  • To carry information, use solid colors or grey shades
  • *Only in desperation*, use parallel lines or cross-hatching

Color vs. Black-and-White
  • No categories--black and white
  • Few categories--grey shades
  • Many categories--color (sometimes grey shades hard to distinguish)

Axes
  • Turn off axis lines (they tell nothing)
  • Turn off tick marks
  • If not turning off axis labels, supply your own
  • Label (invisible) tick marks sparingly, to emphasize key information--
    Make the graph talk (Figure 7)

Axis Ranges
  • De-accentuate fluctuations--
    Start axis at zero, *not* the SAS/GRAPH default
    Prevent needless anxiety, questions
  • For percents, use range 0-100 (& label the ends)
    Bar length = visual percent
    Absolute maximum is natural choice
  • For trend chart issued monthly, use fixed number of months

Bessler’s Enhanced Horizontal Bar Chart (Figure 5)
A foolproof, better alternative to the Pie Chart
  • Image & detail optimally combined:
    category, percent of whole, visual size, value
  • Always works, even when pie chart fails (i.e.,
    when labels of small slices vanish, as in Figure 2).
    Figure 5 is infeasible as a pie chart.

Vertical Bar Charts
  • Consider annotation
    for *simple* vertical bar charts (Figures 6 & 7)
  • If complex, use parallel, not stacked, bars
    (Figure 8 vs. Figure 9)
  • For complex vertical bar chart, use PROC GREPLAY with a template to put the bar chart
    above, and a table below for detail look-up (Figure 10)

Order of Pie Slices (Figure 2 vs. Figure 3)
  • Default--by slice name
  • More useful--Release 6.07 option:
    *DESCENDING* (i.e., by decreasing slice size)
    If Release 6.07 not available, use *MIDPOINTS =*, with list ordered right

Pie Labels
  • Specify NOHEADING
  • All OUTSIDE
  • *Do not* match color of label to that of slice--e.g.,
    yellow text on white paper is impossible to read
  • SAS/GRAPH-computed PERCENT always
    *NN.NN%*: Circumvent using technique shown in Program 3 (see Appendix) and Figure 3
  • SAS/GRAPH appends .0 to integer VALUEs:
    Suppress with FORMAT statement

I Call It the Pac-Man Pie Chart (Figure 1)
Is this picture “worth a thousand words”?
  • A picture is more memorable!
  • *Images stick, after are numbers forgotten*—there
    have been reports that the use of images, in
    addition to text, improves, e.g., effectiveness of
    fundraising and memory of request.

<table>
<thead>
<tr>
<th>Mainframe Data Analysis Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Shares</td>
</tr>
<tr>
<td><strong>SAS - 82%</strong></td>
</tr>
<tr>
<td><strong>Other - 18%</strong></td>
</tr>
</tbody>
</table>

*Source: Computer Intelligence, August 1991*

Figure 1. Pac-Man Pie Chart: not worth a thousand words, but memorable
SAS/GRAPH pie charts tend to lose the SLICE, VALUE, and PERCENT text if there are too many slices, especially for the small ones. They work best for only a few slices.

The Pac-Man Pie Chart is an excellent use of the pie chart. And if the smaller slice needs detail provided, that can be put (with the big slice information as well) in a ranked-list table.

My Enhanced Horizontal Bar Chart is a superior alternative to the over-used pie chart. Besides course, compare magnitudes, and can display trends or changes.

Line plots are good for trends. However, if it’s a multi-line plot with too much crisscrossing, a side-by-side bar chart is often a better alternative. But, if one wishes to annotate the data points, even the case that could be handled by a single-line plot is better served by a simple bar chart—for which there is no chance of the value being obscured by a line.

If much detail is required, it always belongs in a companion or stand-alone table.

Notices

For more on SAS/GRAPHic communication design, see the author’s paper Effective and Efficient Use of SAS/GRAPH Software, elsewhere in these Proceedings.

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SAS System Release 5.18 was used for this paper.

The SAS code listed in the Appendix was tested, and is reliable. In any case, code can only be presented “as is”. Any code adopted by you should be tested by you, and you must assume responsibility for the consequences of its use. It must be tested, and might require modification, for compatibility with Version 6.

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Program 4: SAS/GRAPH statements for Figure 4

```sas
/* OPTIONS and DATA step same as for Program 4 */ /* Run INMIDPT has format $11. */ PROC SORT DATA=INDATA OUT=SORTED; BY INMIDPT; RUN;
PROC FREE DATA=SORTED; TABLE INMIDPT / OUT-PERCENT NOMICRT WEIGHT RESPONSE; RUN;
DATA DATA INMIDPT SUMRESPONSE;
OUTPUT;
RUN;
/* OPTIONS and DATA step same as for Program 4 */ /* Run INMIDPT has format $11. */ OPTIONS VARCHAR=30;
DATA INDATA;
INFILE CARDS;
INPUT
Q06 RESPONSE
MIDPOINT
SUMVAR=RESPONSE;
MIDPOINT = &MIDPOINT;
MIDPNT = &MIDPNT;
RETAIN FUNCTION 'LABEL' 'COLOR 'BLACK' ;
COLOR 'BLACK' ;
MIDPNT = &MIDPNT ,ENDLABEL=RESPONSE, LABELFMT:Z3.1);
MIDPNT=MIDPNT ,ENDLABEL=PCTCHANG,LABELFMT=$6.);
RUN;
/* OPTIONS and DATA step same as for Program 4 */ /* Run INMIDPT has format $11. */ OPTIONS VARCHAR=30;
DATA INDATA;
INFILE CARDS;
INPUT
Q06 RESPONSE
MIDPOINT
SUMVAR=RESPONSE;
MIDPOINT = &MIDPNT;
RETAIN FUNCTION 'LABEL' 'COLOR 'BLACK' ;
COLOR 'BLACK' ;
MIDPNT = &MIDPNT ,ENDLABEL=RESPONSE, LABELFMT:Z3.1);
MIDPNT=MIDPNT ,ENDLABEL=PCTCHANG,LABELFMT=$6.);
RUN;
/* OPTIONS and DATA step same as for Program 4 */ /* Run INMIDPT has format $11. */ OPTIONS VARCHAR=30;
DATA INDATA;
INFILE CARDS;
INPUT
Q06 RESPONSE
MIDPOINT
SUMVAR=RESPONSE;
MIDPOINT = &MIDPNT;
RETAIN FUNCTION 'LABEL' 'COLOR 'BLACK' ;
COLOR 'BLACK' ;
MIDPNT = &MIDPNT ,ENDLABEL=RESPONSE, LABELFMT:Z3.1);
MIDPNT=MIDPNT ,ENDLABEL=PCTCHANG,LABELFMT=$6.);
RUN;
/* OPTIONS and DATA step same as for Program 4 */ /* Run INMIDPT has format $11. */ OPTIONS VARCHAR=30;
DATA INDATA;
INFILE CARDS;
INPUT
Q06 RESPONSE
MIDPOINT
SUMVAR=RESPONSE;
MIDPOINT = &MIDPNT;
RETAIN FUNCTION 'LABEL' 'COLOR 'BLACK' ;
COLOR 'BLACK' ;
MIDPNT = &MIDPNT ,ENDLABEL=RESPONSE, LABELFMT:Z3.1);
MIDPNT=MIDPNT ,ENDLABEL=PCTCHANG,LABELFMT=$6.);
RUN;
/* OPTIONS and DATA step same as for Program 4 */ /* Run INMIDPT has format $11. */ OPTIONS VARCHAR=30;
DATA INDATA;
INFILE CARDS;
INPUT
Q06 RESPONSE
MIDPOINT
SUMVAR=RESPONSE;
MIDPOINT = &MIDPNT;
RETAIN FUNCTION 'LABEL' 'COLOR 'BLACK' ;
COLOR 'BLACK' ;
MIDPNT = &MIDPNT ,ENDLABEL=RESPONSE, LABELFMT:Z3.1);
MIDPNT=MIDPNT ,ENDLABEL=PCTCHANG,LABELFMT=$6.);
RUN;
```

Program 5: SAS/GRAPH statements for Figure 5

```sas
/* OPTIONS and DATA step same as for Program 5 */ OPTIONS VARCHAR=30;
DATA INDATA;
INFILE CARDS;
INPUT
Q06 RESPONSE
MIDPOINT
SUMVAR=RESPONSE;
MIDPOINT = &MIDPNT;
RETAIN FUNCTION 'LABEL' 'COLOR 'BLACK' ;
COLOR 'BLACK' ;
MIDPNT = &MIDPNT ,ENDLABEL=RESPONSE, LABELFMT:Z3.1);
MIDPNT=MIDPNT ,ENDLABEL=PCTCHANG,LABELFMT=$6.);
RUN;
```

Program 6: SAS/GRAPH statements for Figure 6

```sas
/* OPTIONS and DATA step same as for Program 6 */ OPTIONS VARCHAR=30;
DATA INDATA;
INFILE CARDS;
INPUT
Q06 RESPONSE
MIDPOINT
SUMVAR=RESPONSE;
MIDPOINT = &MIDPNT;
RETAIN FUNCTION 'LABEL' 'COLOR 'BLACK' ;
COLOR 'BLACK' ;
MIDPNT = &MIDPNT ,ENDLABEL=RESPONSE, LABELFMT:Z3.1);
MIDPNT=MIDPNT ,ENDLABEL=PCTCHANG,LABELFMT=$6.);
RUN;
```

Program 7: SAS/GRAPH statements for Figure 7

```sas
/* OPTIONS and DATA step same as for Program 7 */ OPTIONS VARCHAR=30;
DATA INDATA;
INFILE CARDS;
INPUT
Q06 RESPONSE
MIDPOINT
SUMVAR=RESPONSE;
MIDPOINT = &MIDPNT;
RETAIN FUNCTION 'LABEL' 'COLOR 'BLACK' ;
COLOR 'BLACK' ;
MIDPNT = &MIDPNT ,ENDLABEL=RESPONSE, LABELFMT:Z3.1);
MIDPNT=MIDPNT ,ENDLABEL=PCTCHANG,LABELFMT=$6.);
RUN;
```
```
/* put GOPTIONS statements here */
GOPTIONS VPOS='30' VSIZE='5;
DATA INDATA;
INFILE CARDS;
INPUT YYMM $16. / - max. 16 characters for legend label */
INPUT '18 YYHM ti.' '23 RESPONSE CaMMAl.;
CARDS;
Bocce '9101 62,188
Croquet '9101 73,467
Bocce '9102 27,920
Croquet '9102 60,879
Bocce '9103 91,644
Croquet '9103 92,639
Bocce '9104 42,161
Croquet '9104 91,814
Bocce '9105 57,467
Croquet '9105 92,639
Bocce '9106 35,896
Croquet '9106 105,319
Bocce '9107 38,538
Croquet '9107 99,411
Bocce '9108 38,488
Croquet '9108 108,856
Bocce '9109 38,488
Croquet '9109 99,006
Bocce '9110 40,296
Croquet '9110 101,507
RUN;
TITLE H='1991 Club Sports Revenues, By Month';
TITLE2 H='1'; TITLE H to change title/chart separation /
FOOTNOTE 'Figure 8. text for figure caption';
PATTERN V=E;
PATTERN2 V=X2;
PROC GCHART DATA=INDATA;
VAR YYMM /
SUBGROUP CLASS /;
SUMVAR RESPONSE;
DISCRETE;
LEGEND LEGEND/;
MAXIS AXISI;
RAXIS AXIS2;
SPACE -112;
WIDTH 3;
LEGENDI LABEL='NONE' DOWN='I';
AXISI LABEL='NONE' MAJOR='NONE' MINOR='NONE' STYLE=0
ORDER= 'Bocce' 'Croquet' 'Total';
VALUE=('Jan' 'Feb' 'Mar' 'Apr' 'May' 'Jun');
AXIS2 LABEL='NONE' MAJOR='NONE' MINOR='NONE' STYLE=0
ORDER= 0 TO 175000 BY 25000;
FORMAT RESPONSE DOLLARS.;
RUN;
Program 8: SAS/GRAPH statements for Figure 8
```

```
/* put GOPTIONS statements here */
GOPTIONS VPOS=50 VISIZE=(5);
DATA INDATA;
INFILE CARDS;
INPUT 0101 CLASS $16. / - max. 16 characters for legend label */
INPUT '18 YYHM ti.' '23 RESPONSE CaMMAl.;
CARDS;
Bocce '9101 62,188
Croquet '9101 73,467
Bocce '9102 27,920
Croquet '9102 60,879
Bocce '9103 91,644
Croquet '9103 92,639
Bocce '9104 42,161
Croquet '9104 91,814
Bocce '9105 57,467
Croquet '9105 92,639
Bocce '9106 35,896
Croquet '9106 105,319
Bocce '9107 38,538
Croquet '9107 99,411
Bocce '9108 38,488
Croquet '9108 108,856
Bocce '9109 38,488
Croquet '9109 99,006
Bocce '9110 40,296
Croquet '9110 101,507
RUN;
TITLE H='1991 Club Sports Revenues, By Month';
TITLE2 H='1'; TITLE H to change title/chart separation /
FOOTNOTE 'Figure 9. text for figure caption';
PATTERN V=E;
PATTERN2 V=X2;
PATTERN3 V=S;
PROC GCHART DATA=INDATA;
VBAR YYMM /;
SUBGROUP = CLASS
SUMVAR = RESPONSE
DISCRETE;
LEGEND = LEGEND1
AXIS = AXIS2
SPACE = 3;
LEGENDI LABEL='NONE' DOWN='I';
AXISI LABEL='NONE' MAJOR='NONE' MINOR='NONE' STYLE=0
ORDER= 'Bocce' 'Croquet' 'Total';
VALUE=('Jan' 'Feb' 'Mar' 'Apr' 'May' 'Jun');
AXIS2 LABEL='NONE' MAJOR='NONE' MINOR='NONE' STYLE=0
ORDER= 0 TO 175000 BY 25000;
FORMAT RESPONSE DOLLARS.;
RUN;
Program 9: SAS/GRAPH statements for Figure 9
```
1989 U.S. Alcoholic Beverage Consumption, Gallons Per Capita
SUM OF RESPONSE BY INMIDPT

Data Source: John C. Maxwell, Jr., Wheat First Securities
Reported in: "Beverage Industry", February 1990

Figure 2. Bad Pie Chart, Using SAS/GRAPH Defaults and Option PERCENT=OUTSIDE

1989 U.S. Alcoholic Beverage Consumption, Gallons Per Capita

Data Source: John C. Maxwell, Jr., Wheat First Securities
Reported in: "Beverage Industry", February 1990

Figure 3. Custom Pie Chart with Better Percents, and DESCENDING Slice Sizes
1990 Population in the European Community, By Country

<table>
<thead>
<tr>
<th>Country</th>
<th>Millions Sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>9.9</td>
</tr>
<tr>
<td>Denmark</td>
<td>5.1</td>
</tr>
<tr>
<td>France</td>
<td>56.4</td>
</tr>
<tr>
<td>Germany</td>
<td>78.5</td>
</tr>
<tr>
<td>Greece</td>
<td>10.0</td>
</tr>
<tr>
<td>Ireland</td>
<td>3.5</td>
</tr>
<tr>
<td>Italy</td>
<td>57.7</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>0.4</td>
</tr>
<tr>
<td>Netherlands</td>
<td>14.9</td>
</tr>
<tr>
<td>Portugal</td>
<td>10.4</td>
</tr>
<tr>
<td>Spain</td>
<td>39.3</td>
</tr>
<tr>
<td>U.K.</td>
<td>57.4</td>
</tr>
</tbody>
</table>

Source: "The World Factbook 1990"

Figure 4. Horizontal Bar Chart, Using SAS/GRAPH Defaults

1990 Population in the European Community, By Country

<table>
<thead>
<tr>
<th>Country</th>
<th>Share</th>
<th>Millions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>22.9%</td>
<td>78.5</td>
</tr>
<tr>
<td>Italy</td>
<td>16.8%</td>
<td>57.7</td>
</tr>
<tr>
<td>U.K.</td>
<td>16.7%</td>
<td>57.4</td>
</tr>
<tr>
<td>France</td>
<td>16.4%</td>
<td>56.4</td>
</tr>
<tr>
<td>Spain</td>
<td>11.4%</td>
<td>39.3</td>
</tr>
<tr>
<td>Netherlands</td>
<td>4.3%</td>
<td>14.9</td>
</tr>
<tr>
<td>Portugal</td>
<td>3.0%</td>
<td>10.4</td>
</tr>
<tr>
<td>Greece</td>
<td>2.9%</td>
<td>10.0</td>
</tr>
<tr>
<td>Belgium</td>
<td>2.9%</td>
<td>9.9</td>
</tr>
<tr>
<td>Denmark</td>
<td>1.5%</td>
<td>5.1</td>
</tr>
<tr>
<td>Ireland</td>
<td>1.0%</td>
<td>3.5</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>0.1%</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Source: "The World Factbook 1990"

Figure 5. Customized Horizontal Bar Chart, Showing Category, Percent, & Value

Total = 343.5
Local Tax Levy, 1986 to 1992
(Millions of Dollars)

2.5 2.8 2.9 3.0 3.1 3.2 3.4

Figure 6. Customized Vertical Bar Chart (Version 6 displays bar-top values)

Local Tax Levy, 1986 to 1992
(Millions of Dollars, and Annual Percent Change)

$3.4M
$2.5M
0

Figure 7. Customized Vertical Bar Chart, Annotated with Percent Change
1991 Club Sports Revenues, By Month

Figure 8. Stacked Vertical Bar Chart for "Additive" Trends—Not Recommended

1991 Club Sports Revenues, By Month

Figure 9. Parallel Vertical Bar Chart for "Additive" Trends, With Total Bar
1991 Club Sports Revenues, By Month

$151,894

<table>
<thead>
<tr>
<th>Month</th>
<th>Bocce</th>
<th>Croquet</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>$62,188</td>
<td>$73,962</td>
<td>$136,150</td>
</tr>
<tr>
<td>Feb</td>
<td>$27,920</td>
<td>$85,079</td>
<td>$112,999</td>
</tr>
<tr>
<td>Mar</td>
<td>$59,741</td>
<td>$91,144</td>
<td>$150,885</td>
</tr>
<tr>
<td>Apr</td>
<td>$57,467</td>
<td>$92,639</td>
<td>$150,106</td>
</tr>
<tr>
<td>May</td>
<td>$42,691</td>
<td>$101,361</td>
<td>$144,052</td>
</tr>
<tr>
<td>Jun</td>
<td>$35,896</td>
<td>$105,319</td>
<td>$141,215</td>
</tr>
<tr>
<td>Jul</td>
<td>$38,538</td>
<td>$99,411</td>
<td>$137,949</td>
</tr>
<tr>
<td>Aug</td>
<td>$43,038</td>
<td>$108,856</td>
<td>$151,894</td>
</tr>
<tr>
<td>Sep</td>
<td>$38,444</td>
<td>$99,006</td>
<td>$137,450</td>
</tr>
<tr>
<td>Oct</td>
<td>$40,296</td>
<td>$104,507</td>
<td>$144,803</td>
</tr>
<tr>
<td>Nov</td>
<td>$40,201</td>
<td>$110,826</td>
<td>$151,027</td>
</tr>
<tr>
<td>Dec</td>
<td>$32,776</td>
<td>$98,928</td>
<td>$131,704</td>
</tr>
</tbody>
</table>

Figure 10. Parallel Vertical Bar Chart, with Table for Detail Look-up